Performance Improvements to the 802.11 Wireless Network Medium Access Control Sub-layer

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ABSTRACT

This thesis presents the outcome into the research and development of improvements to the 802.11 wireless networking medium access control (MAC) sublayer. The main products of the research are three types of improvement that increase the efficiency and throughput of the 802.11 protocol.

Beginning with an overview of the original 802.11 physical layer and MAC sub-layer standard, the introductory chapters then cover the many supplements to the original standard (including a brief on the future 802.11n supplement). The current state of the 802.11 MAC sub-layer is presented along with an assessment of the realistic performance available from 802.11. Lastly, the motivations for improving the MAC sub-layer are explained along with a summary of existing research into this area.

The main improvement presented within the thesis is that of packet aggregation. The operation of aggregation is explained in detail, along with the reasons for the significant available throughput increase to 802.11 from aggregation. Aggregation is then developed to produce even higher throughput, and to be a more robust mechanism. Additionally, aggregation is formally described in the form of an update to the existing 802.11 standard.

Following this, two more improvements are shown that can be used wither with or without the aggregation mechanism. Stored frame headers are designed to reduce repetition of control data, and combined acknowledgements are an expansion of the block acknowledgement system introduced in the 802.11e supplement.

This is followed by a description of the simulation environment used to test the three improvements presented, such as the settings used and metrics created. The results of the simulations of the improvements are presented along with the discussion. The developments to the basic improvements are also simulated and discussed in the same way.

Finally, conclusions about the improvements detailed and the results shown in the simulations are drawn. Also at the end of the thesis, the possible future direction of research into the improvements is given, as well as the aspects and issues of implementing aggregation on a personal computer based platform.

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1 INTRODUCTION

The introduction to this thesis covers both the literature survey, and the background information, beginning with the general background and scope of the research. Then the remaining introduction is divided into three separate and distinct chapters following the overall introduction that provide a more detailed look at the facts of wireless networks.

The first of these covers the Institute of Electronic and Electrical Engineers (IEEE) 802.11 family of wireless local area network standards, where they come from and where are they headed. Secondly, the current 802.11 Medium Access Control (MAC) layer is analysed to find where and why it needs attention, and thirdly a summary of the existing ideas proposed for the improvement of the MAC sub-layer is presented.

1.1 BACKGROUND

The initial intention for this research was formulated during the years leading up to the conclusion of my undergraduate course. I developed an interest in wireless networks, and began to look beneath the surface, seeking the ability to understand the features of wireless networks - in particular the IEEE 802.11 standard used for Wireless Local Area Networks (WLAN).

Perhaps the most interesting facet of this topic was the use of 802.11's ad-hoc mode to create a wireless mesh network. Wireless mesh networks need no existing infrastructure – rather they simply and solely use the stations (wireless network devices) themselves. If two stations are out of range of each other, they form a route through other stations.

Many of these networks have been created across the globe. These have been largely private undertakings by groups of friends, neighbourhoods, municipal councils and many other organisations. They exist to improve connections between the members of these groups, or in many cases to create connections where none existed before.

However, while the connections are created, the throughput offered over the connections is often not great, and can be much lower than the notional maximum speed. This research was initially started to understand why the notional speeds were never attained in real world deployments. Once the reasons were found and understood, it was hoped that improvements could be found that would rectify the problem and provide a better service to the users of WLANs.

The main problem this research is targeted towards is the improvement of the throughput of 802.11 wireless networks. The improvements investigated within the research are also presented alongside some other improvements to the 802.11 standard that are focused upon other performances metrics – for example, greater priority for multimedia traffic.

The improvements detailed within this research, and the other improvements mentioned, have the goal of improving the user experience of 802.11 wireless networks. All of the improvements are part of an ongoing push for better performance, greater efficiency, improved robustness and stability and an overall maturity for the collection of 802.11 standards.

1.2 Content of Thesis

Firstly, the overall 802.11 standard is introduced as part of the IEEE's group of 802 networking standards. This is followed with an overview of the general operation of 802.11, as well as descriptions for the wide range of physical and MAC sub-layer supplements. This includes the 802.11a, 802.11b and 802.11g physical layer extensions, and the 802.11e MAC sub-layer extension. Also, the next generation version – 802.11n – is discussed.

After this, the need for improving the MAC sub-layer is detailed. This includes a look at the realistic performance delivered by the current set of extensions, and a look at the typical traffic distribution likely over a wireless network. This is followed by the current state of research into improving the MAC sub-layer, as well as an assessment of chipsets that claim to implement improvements.

Then the main improvement targeted in this research – packet aggregation – is introduced as a mechanism to significantly reduce the overheads of the 802.11 operation, and thus improve throughput. Three chapters are dedicated to aggregation, with the first detailing the two main types of aggregation and their respective operation, as well as how packet queues operate within an aggregator. This is followed by a chapter dealing with the development of specific parts of the aggregation mechanism in order to gain efficiency and cope with interference. The third chapter formally describes aggregation as an update to the existing 802.11 standard using the same formal description methods as the standard specification.

Then two more improvements to the MAC sub-layer are presented. Combined acknowledgements reduce the overhead incurred by the acknowledgement system of 802.11, thus giving an increase in the possible maximum throughput. A stored frame header system aims to improve the performance of static wireless links, such as a fixed point to point wireless link.

The design and details of the simulation environment for the assessment of the improvements is described. This is followed by a presentation and discussion of the results of the simulation of the improvements.

Finally, conclusions are made both against the objectives of the research presented by the thesis, and about the outcome of the individual improvements. Also included are comments about the future direction of this research.